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Justifying Process Control Computers

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CONSIDER ALL POTENTIAL SAVINGS WHEN

JUSTIFYING PROCESS CONTROL COMPUTERS

The obvious benefits of process control computer systems—for which dollar values are easily determined in the justification stage—have been well publicized. Not so well known or appreciated are additional, intangible benefits that often are revealed only after a system has been operational for some time. The authors identify a number of these hidden benefits and cite examples where such benefits have contributed significantly to the over-all worth of a number of computer projects.

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MOST process control computer systems are justified economically on the basis of tangible, easily determined benefits such as increased throughput, better and more consistent product quality, and savings in raw materials. In many cases, however, additional benefits are realized after a system has been operating for some time. These benefits—which are sometimes intangible, or hidden, at the inception of a computer project—can become positive economic virtues in the subsequent operational phase.

The fact that many computer projects have resulted in greater savings than were originally anticipated suggests that certain indirect benefits exist which should be considered, along with the tangible benefits, in the system justification stage. Some of the indirect, or hidden, benefits that have been obtained with process control computer systems will be

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TABLE 1 - Typical Payouts for Industrial Process Computer Installations

Company	Estimated Savings ($1000/ Year)	Actual Payout ($1000/ Year)
"A"	270	$ 500[1]
"B"	465	1000
"C"	140	300[2]
"D"	300	500[3]

[1]Based on 350 operating days per year; reported to be as high as $2800 per day.

[2]Based on 70 per cent on-line computer usage; customer reports 15 per cent increase in production.

[3]Customer reports 12 per cent decrease in raw material expense in first year of operation; additional 7.4 per cent decrease in second year.

described following a review of computer control and the direct benefits that normally favor its adoption.

Computer Control Defined

Basically, computer control is the direct manipulation of control elements and/or setpoints of a process based on the solution of a set of equations stored in the computer's memory. These stored equations describe, in mathematical terms, the operation of the unit to be controlled. The stored information, commonly referred to as the control program, consists of:

Mathematical Model. This is a series of equations that state the interrelationships of a group of mathematical expressions describing the physical and chemical events occurring in a process.

Set of Constraint Equations. These equations describe the physical limitations of the equipment and the chemical thermodynamic restraints of the process.

Technique for Optimization. A method for selecting the best set of operating variables based on current unit objectives and location of constraints.

Procedure for Updating. The coefficients of the stored

Hidden Benefits of Computer Control

1. **More Complete and Accurate Operating Data.** A computer system accurately logs all important process variables and prints the results of important calculations such as yields, efficiencies, operating guides, and flow (compensated and totaled). These functions greatly assist plant operators, supervisors, and accounting departments. Typical benefits are:

Reduced process losses. In a chemical plant, recorded operating data indicated that an operator had made an error in valving while transferring material in the plant, causing a valuable product to be discharged to atmosphere. In another plant, a valuable product was being sent to fuel. The computer, by accounting for all material flows, can prevent this type of loss of valuable products.

Smoother over-all plant operation. At a crude unit installation, logged column heat and material indicated that the feed was being overflashed by 70 per cent. It was found that the internal reflux traffic (not directly available to the operator) was seven times greater than required, resulting in excessive consumption of utilities. Corrective measures were taken to bring the flash percentage closer to design conditions.

Accounting savings. An accurate calculation of material and energy flows within the plant is provided by a computer. In addition, the task of analyzing charts with a planimeter is eliminated.

2. **Better Technical Information About the Process.** In addition to providing more accurate and frequent data, a computer collects plant data during upsets. Data accumulated during these periods is extremely valuable, but is normally unobtainable where manual logging is used since the operators are too busy during such periods.

A computer system can also be made available to a process engineer for special tests. The computer then will control the test, collect the data, perform necessary calculations, and provide final results to the engineer.

Of prime importance in studies directed toward improving certain processes is an accurate description of the process mechanism and its kinetics. Analyzing the data provides a means for developing and verifying concepts for process improvement.

With a computer, information is developed automatically as a part of the control program. Thus, a good insight can be gained into the actual state of the process by observing changes made to the control model by the updating features incorporated in the computer program.

As a result of information gained by a computer about their processes, many users have been able to modify their processes and achieve additional gains almost as great as those from actual computer control.

3. **Automatic Indication of Malfunctions.** A control computer system typically receives 200 analog signals from process measuring instruments. Each input signal can be used to check the functioning of the instrument, determine whether or not the variable is out of limits, determine how rapidly the variable is changing, and check for more complex operating difficulties and process equipment malfunctions by a combination of signals.

The typical computer system also offers a 200-point alarm system with the ability to alarm on single or combined inputs. It is difficult to place a dollar value on this feature, however, an equivalent level of safety might require the installation of 200 conventional alarm systems.

4. **Better Control.** Unlike an operator, a computer has the ability to change more than one variable at a time, and can take into account the interaction of these variables. For example, in order to compensate for an uncontrollable variation in feed composition to an ammonia synthesis reactor, an operator will vary the inlet temperature or the feed rate to avoid unstable operation. A computer system, on the other hand, will alter both temperature and feed rate simultaneously to sustain optimum operation.

At a "cat cracker" installation, the unit is operated to utilize all the air available. On occasions, under manual control, the cat cracker would make more carbon than could be burned. Since the catalyst was continually circulating, each pass added still more carbon. The effect would "snow-ball" and cause unstable operation. To restore normal operation, the feed rate had to be lowered, steam had to be added, and excess coke was burned off. The computer avoids such occurrences since it can calculate hard-to-determine variables such as per cent carbon-on-coke and, when necessary, take compensating control actions.

5. **Data Analysis and Complex Calculations.** An on-line digital computer collects, measures, and records large amounts of data. Each measurement is automatically analyzed as it is made and, when desired, the computer records only data from specified operating conditions. This eliminates the need for reviewing substantial quantities of insignificant

equations are updated, as required, to reflect current values of the output variables of yields, separation efficiencies, catalyst activity, etc.

An internally programmed, general purpose, digital control computer installation usually costs in the range of $200,000 to $300,000 or more. Therefore, it is important to make sure that the process can justify the installation.

A process with a high capacity, in which a small increase in efficiency can result in large savings, is an ideal candidate for computer control. An increase in product efficiency from 0.5 to 1 per cent, in many cases, would be enough to justify an installation for such a process.

In many cases, labor savings are an important item of justification. However, many firms—especially those in the chemical and petroleum industries—have already reduced their labor forces during the instrumentation stages of automation. With the inclusion of a control computer, the existing operating force remains. Now the operators have redefined roles; namely, to assume control of the plant in case of equipment failure or if the process encounters any situation that the control scheme cannot handle.

▶ Direct Benefits

A control computer transcends human capability by applying preplanned intelligence to the over-all economic operation of the process. Generally, this

data usually associated with a noncomputing data logger system.

In addition to performing rudimentary computations, an on-line computer can perform complex calculations determining such things as tray efficiencies and heat transfer coefficients. In one installation where a distillation column is kept loaded at all times, the printed tray efficiencies permit detection of incipient flooding and entrainment, thus avoiding unstable operation.

In another plant, a computer describes the operation of condensers, reboilers, and heat exchangers in determining optimum operating conditions. An intermediate calculation yields heat transfer coefficients that are printed out for use by the maintenance department in scheduling operations.

6. Increased Process Knowledge During Analysis Phase. A computer system is designed to sample process data at a specified rate and to rapidly make either major adjustments of controller set points or to adjust these set points over a long time interval. The frequency of sampling and manner of adjustment are specified by commands stored in the computer's memory. In complicated processes with material and/or energy feedback, a knowledge of the dynamics of the process and its controlling instruments is required to avoid introducing process instability.

Under these conditions, an on-line computer can extensively analyze all measurements and determine the dynamic process characteristics. It can also be used to verify off-line simulation of the process and of the sample data system. Other areas where increased process knowledge has been obtained through the use of a computer include system kinetics, gathering of better thermodynamic data, and verifying feasibility of new control schemes.

7. Automatic Computation of Gas Chromatographic Data. For this operation, analog voltages are read by an on-line digital computer system at a predetermined interval directly from the chromatograph detector. The computer, through its stored program, uses this information to locate peaks, detect unresolved peaks, integrate areas, and correct the areas for base line drift. After applying the required calibrated factors, the component and composition is stored in the computer's memory or printed out on a logging typewriter.

The computer method is more efficient and accurate than certain other devices used to handle chromatographic data, since no manual scanning of the chromatograph, or use of automatic locators, are required to locate peaks.

8. Better Utilization of Personnel. Relatively few operating personnel have been displaced by process control computer systems. What has occurred is the upgrading of personnel in their job areas. Thus, men with long experience have the opportunity to utilize their skills to a greater degree. The installation of a computer system relieves these men of the tedious chores associated with monitoring and readjusting process instruments and with manually logging reams of data. Instead, they have more time to assume the supervisory aspects of their jobs.

In many cases, plant operators have been spurred to greater degrees of efficiency by the installation of a computer system. One plant periodically allows the operators to take over manually in a "contest" with the computer to determine if manual or computer operation is more accurate. Invariably the computer wins, but the operators are not discouraged; they gain an appreciation of the assistance rendered by the computer, and sharpen their skills in areas where man is supreme.

9. Improved Plant Safety. In plants with potential explosion hazards or prospects of runaway conditions in reactors, the computer has the ability to increase the safety of plant operators. The computer continually scans and monitors critical variables in the process and will instantly indicate when hazardous conditions are imminent.

In order to achieve a level of safety that is unattainable by simply scanning individual variables, a computer can also calculate and check certain combinations of variables that might be indicative of hazardous conditions. Alarms are then given far enough in advance so that corrective measures can be taken to avoid catastrophies.

10. Accurate Scheduling and Inventory Control. Some companies use the computer output as an integral part of an over-all management information system to obtain accurate scheduling and inventory control. The digital information, punched out on paper tape or cards, is fed to business data computers for further processing.

Immediate knowledge of daily operations in multiproduct plants has enabled plant managers to schedule production more accurately and to maintain closer inventory control. In a Bunker-Ramo computer-controlled ethylene unit, where naphtha is cracked into a number of salable products, this procedure has resulted in large savings. Not only were raw material costs lowered by eliminating surplus inventory, but considerable savings in space, equipment, and manpower were also effected.

can result in: 1. Increased production. 2. Improved quality control. 3. Reduced operating costs. These direct benefits can be estimated with a high degree of accuracy, and form the major basis for the economic justification of a control computer installation.

A dollar figure can be placed on these tangible benefits. For example, in a typical ethylene unit (200 million pounds per year), computer control will provide approximately $300,000 per year in savings under market-limited conditions and up to $1 million per year under production-limited conditions.

An installed computer system including all Bunker-Ramo Corp. equipment, engineering, and programming services would cost between $200,000 and $300,000. Instrumentation and process modifications required to facilitate the computer system could run to about $100,000. Based on these costs, and the direct benefits for a 200 million pound per year ethylene plant, the pay-back time for a control computer system, after taxes, would be less than 1 year for a production-limited unit and slightly over 2 years for a market-limited unit.

Hidden Benefits

The extent and magnitude of hidden benefits that can accrue from the use of a process control computer system has been established in several instances. On March 12, 1959, for example, the world's first industrial process to be controlled by a digital computer—Texaco's catalytic polymerization unit No. 1 at Port Arthur, Texas—went on closed-loop operation. The unit was controlled by an RW-300 computer. Before installation of the computer, the unit was operating at an average conversion rate of 80 per cent. After installation and modifications to the unit were completed, the conversion rate increased to 91 per cent—more than enough to pay for the installation of the computer system.

Now, after five years of nearly continuous operation (more than 43,000 hours), a definite fix can be made on the intangible benefits derived from the project. According to Texaco management, these hidden benefits may be of even greater value than the increased conversion rate of the plant. In this particular installation, the hidden benefits include: More complete and accurate operating data, better technical information about the process, automatic indication of malfunctions in the process, and better control.

Since the Texaco installation was made at Port Arthur, the number of control computer installations in the world has mushroomed. To date, nearly 400 industrial control computers have either been installed or are on order. More than two thirds of these computers are in, or slated for, plants in the United States.

Because many of these installations have been in operation for several years, it is now possible to ascertain the value of hidden benefits in some cases. In TABLE 1, for example, are listed actual user payouts for a number of Bunker-Ramo computer installations in a variety of industrial processes. The estimated savings shown were only those on which we could place an actual dollar figure—these are the direct benefits. The column entitled "Actual Payout" takes into account the results of indirect or hidden benefits as well as direct benefits.

Some of the common hidden benefits of computer control that we have been able to observe in more than 35 Bunker-Ramo installations over the past 5 years are identified and described in the box entitled "Hidden Benefits of Computer Control." There are other hidden benefits that are not so obvious and are unique to individual applications.

Management is continually faced with the problem of decreasing profit margins. An effective way of increasing profits, in any industry, is to reduce operating costs. Thus, where a cost reduction proposal is being considered, every effort should be made to evaluate all of the savings that might be realized from adoption of the proposal. Otherwise, a highly profitable scheme could go by the boards through errors of omission.

In the case of on-line computer systems for industrial process control, experience has shown that savings have been realized over and above those normally considered and assigned dollar values in the initial justification phase. Often, these intangible, hidden benefits have brought savings that exceed those realized from tangible sources. Intelligent consideration of these factors can lead to a more accurate appraisal of a computer control system, and/or a shorter pay-back period if a system is acquired.